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SPT

Prelaunch
Mission Operation Report
No. O-492-214-82-01

MAR 30 1982

TO: A/Administrator

FROM: O/Associate Administrator for
Space Transportation Operations

SUBJECT: INSAT-1A Launch on Delta

INSAT-1A is the first in a series of 12-transponder communications satellites developed by the Ford Aerospace and Communications Corporation for the India Department of Space (DOS). It is scheduled to be launched from the Eastern Space and Missile Center (ESMC) no earlier than April 8, 1982. The launch support for this mission will be provided by NASA, on a reimbursable basis, to the DOS for a fixed price of \$25.0M.

The launch vehicle for the INSAT-1A mission will be the Delta 3910 configuration which incorporates an Extended Long Tank Thor booster, nine Castor IV strap-on motors, a TR-201 second stage, and an 8-foot fairing.

The Delta launch vehicle will place the spacecraft along a suborbital trajectory. The McDonnell Douglas commercial PAM-D stage will then thrust it into a synchronous transfer orbit. Five and a half hours after launch, at first apogee, the spacecraft Apogee Kick Motor will be fired to circularize its orbit at geo-synchronous altitude of 19,300 NM above the equator at approximately 74 degrees East Longitude.

A second mission (INSAT-1B) is scheduled for launch on the Space Shuttle in July 1983 (Flt #8).

for Joseph S. Nahon
for Stanley I. Weiss

(NASA-TM-84159) INSAT-1A LAUNCH ON DELTA
(National Aeronautics and Space
Administration) 24 p HC A02/MF A01 CSCL 22A

N 82-21231

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G3/12 09452

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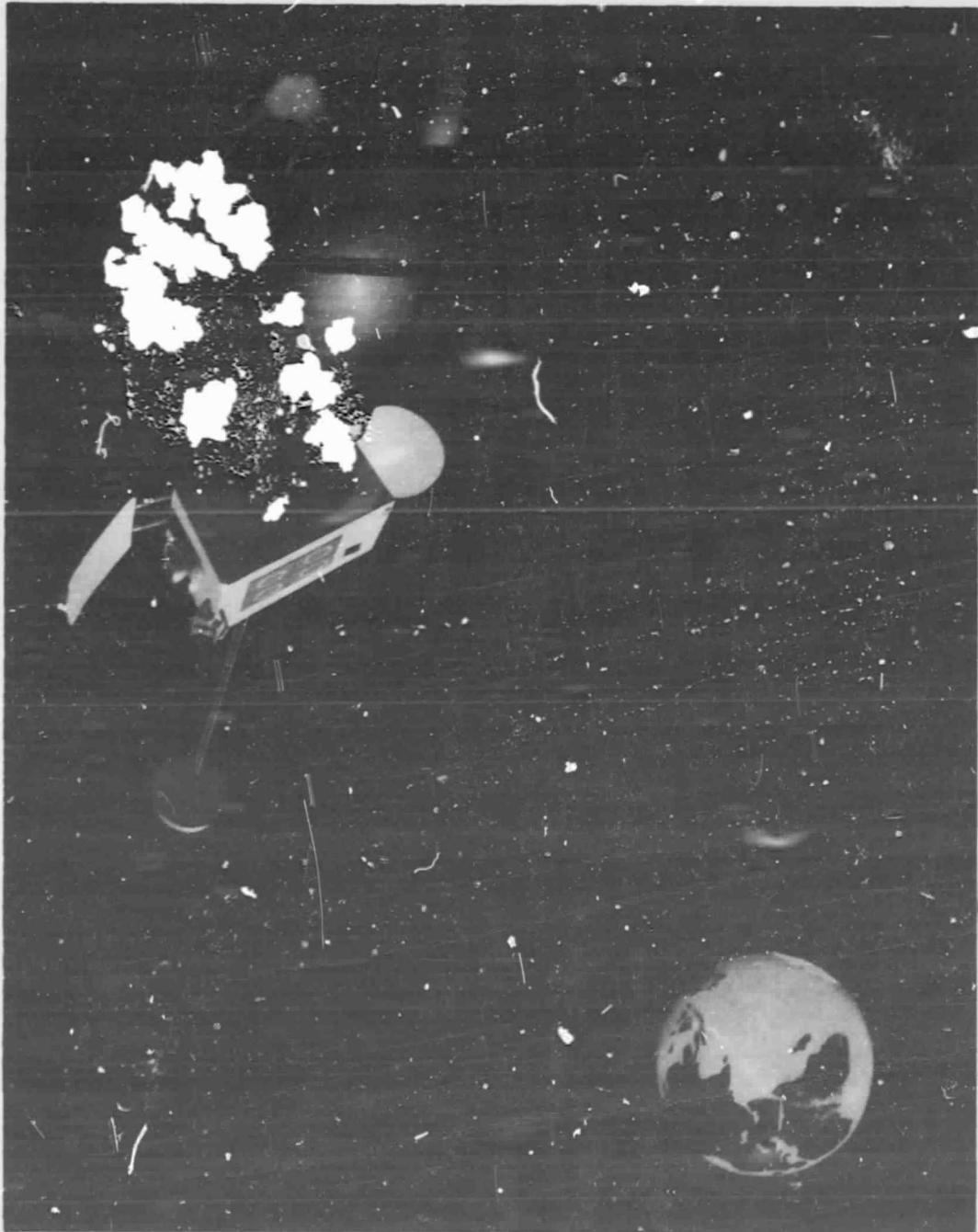
National Aeronautics and
Space Administration

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Mission Operation Report

OFFICE OF SPACE TRANSPORTATION OPERATIONS

Report No. O-492-214-82-01



INS T-1A

FOREWORD

MISSION OPERATION REPORTS are published expressly for the use of NASA Senior Management, as required by the Administrator in NASA Management Instruction HQMI 8610.1A, effective October 1, 1974. The purpose of these reports is to provide NASA Senior Management with timely, complete, and definitive information on flight mission plans, and to establish official Mission Objectives which provide the basis for assessment of mission accomplishment.

Prelaunch reports are prepared and issued for each flight project just prior to launch. Following launch, updating (Post Launch) reports for each mission are issued to keep General Management currently informed of definitive mission results as provided in NASA Management Instruction HQMI 8610.1A.

Primary distribution of these reports is intended for personnel having program/project management responsibilities which sometimes result in a highly technical orientation. The Office of Public Affairs publishes a comprehensive series of reports on NASA flight mission which are available for dissemination to the Press.

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HEADQUARTERS ADMINISTRATION DIVISION
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GENERAL

On July 18, 1978, a Memorandum of Understanding (MOU) was signed between the NASA and the Government of India, Department of Space (DOS), which indicated NASA's agreement to furnish Delta launch of INSAT satellites on a reimbursable basis for India DOS. On November 18, 1980, a Launch Services Agreement (LSA) was signed which set forth detailed terms and conditions for providing this launch support.

In accordance with the LSA:

- NASA will provide support described in the "Delta Standard Services List," dated April 1980, which includes the following services:
 - Provide and launch a Delta 3910 Launch Vehicle to place the INSAT "Payload" into an orbit desired by DOS
 - Provide working area for the spacecraft at ESMC
 - Provide for spacecraft telemetry reception during launch preparation and during the ascent
 - Provide network communications support necessary for launch and initial orbit phase
 - Calculate initial transfer orbit
 - Provide various services, if required, to support the launch
- DOS will undertake to do or certify that the following has been done:
 - Provide mission requirements
 - Assure spacecraft compatibility with launch vehicle and tracking and data facilities
 - Provide a spacecraft interface specification
 - Provide a flight-ready spacecraft to the range
 - Assure to NASA that spacecraft has been properly tested
 - Provide documentation that apogee motor meets range standards
 - Determine launch criteria for spacecraft and supporting stations

The NASA launch support of the INSAT-1A mission is being provided to DOS at a fixed price of \$25.0M for standard services. The LSA has been amended to include several optional services at additional cost to DOS.

* Payload is defined as the INSAT spacecraft, including liquid Apogee Kick Motor, PAM-D Perigee Kick Stage, and all associated adapters, attach fittings, and spin table.

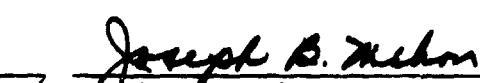
NASA MISSION OBJECTIVES FOR THE INSAT-1A MISSION

Launch the INSAT-1A satellite along a suborbital trajectory on a two-stage Delta 3910 launch vehicle with sufficient accuracy to allow the payload propulsion system to place the spacecraft into a stationary synchronous orbit while retaining sufficient station keeping propulsion to meet the mission lifetime requirements.



Joseph B. Mahon,
Director
Expendable Launch Vehicles
Space Transportation Operations

Date: March 23, 1982



Stanley F. Weiss
Associate Administrator for
Space Transportation Operations

Date: March 20, 1982

MISSION DESCRIPTION

Events from launch to final mission attitude in geostationary orbit occur in a sequence comprised of four basic phases:

- Boost phase, from lift-off through Second Stage Cutoff (SECO), and separation of the payload from the spinning Delta second stage; during this phase, only the command receiver and telemetry transmitter of the spacecraft are active.
- Transfer orbit phase, from second-stage-payload separation to apogee motor ignition; during this phase, the payload spin rate is 40 rpm in Sun-pointing mode. Orientation and spin rate are measured and controlled to provide (a) stable thermal and power conditions during the interval and (b) final orientation for apogee motor firing.

After transfer orbit injection, the spacecraft/PAM combination tumbles for about 20 minutes, reaching a stable spin condition. Spacecraft/PAM separation is done by ground command, followed by despin and attitude acquisition to Sun-pointing mode, with a roll rate of -0.75 degrees/second.

During transfer orbit operations, the spacecraft remains in Sun-pointing mode. About 2 hours prior to first apogee, the spacecraft is reoriented to AKM firing attitude with 3-axis control, and orientation trim corrections are made prior to the first apogee.

- Synchronous orbit injection phase, during which the apogee motor burn increases the magnitude and changes the direction of satellite velocity to effect the change from the inclined, elliptical transfer orbit to the synchronous altitude, equatorial final orbit.

After completion of first AKM firing, the spacecraft spends two revolutions in an intermediate orbit in Sun-pointing mode attitude. About 1 hour before the second AKM firing, the spacecraft is reoriented to AKM firing attitude with 3-axis control. The second AKM firing is targeted to put the spacecraft nominally on-station.

- Drift orbit and erection phase, during which the spin rate of the spacecraft is adjusted to the final system angular momentum range, the spin axis and momentum range, the spin axis and momentum vector are aligned to the orbit normal, and the momentum wheel is energized to cause the body pitch axis to align to the orbit normal. The solar array is then deployed, and Earth capture is accomplished by using Earth sensor error signals to control the momentum wheel rate.

After the second AKM firing, the spacecraft is reoriented to achieve the normal on-orbit 3-axis attitude and station acquisition orbit maneuvers are initiated. The target station longitude is 74 degrees east. This is attained, with dispersion correction burns, in about 36 hours after second AKM firing.

After station acquisition, the spacecraft undergoes full deployment and then commences its geosynchronous phase of operations.

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Once in orbit, the INSAT-1A multipurpose telecommunications/meteorology spacecraft will have a capability for nationwide direct broadcasting to community TV receivers in rural areas over an image area shown in Figure 1. Its orbital location will be 74 degrees East Longitude above the Earth's equator (see Figure 1). Sister spacecraft INSAT-1B, scheduled for a July 1983 launch on Space Shuttle, will occupy a similar equatorial location at 94 degrees East Longitude (see Figure 1). Both spacecraft are built by Ford Aerospace and Communications Corporation under a joint venture of the Department of Space, the Posts and Telegraphs Department (P&T) of the Ministry of Communications, the India Meteorological Department of the Ministry of Tourism and Civil Aviation and the Doordarshan of the Ministry of Information and Broadcasting.

INSAT-1A IMAGING COVERAGE

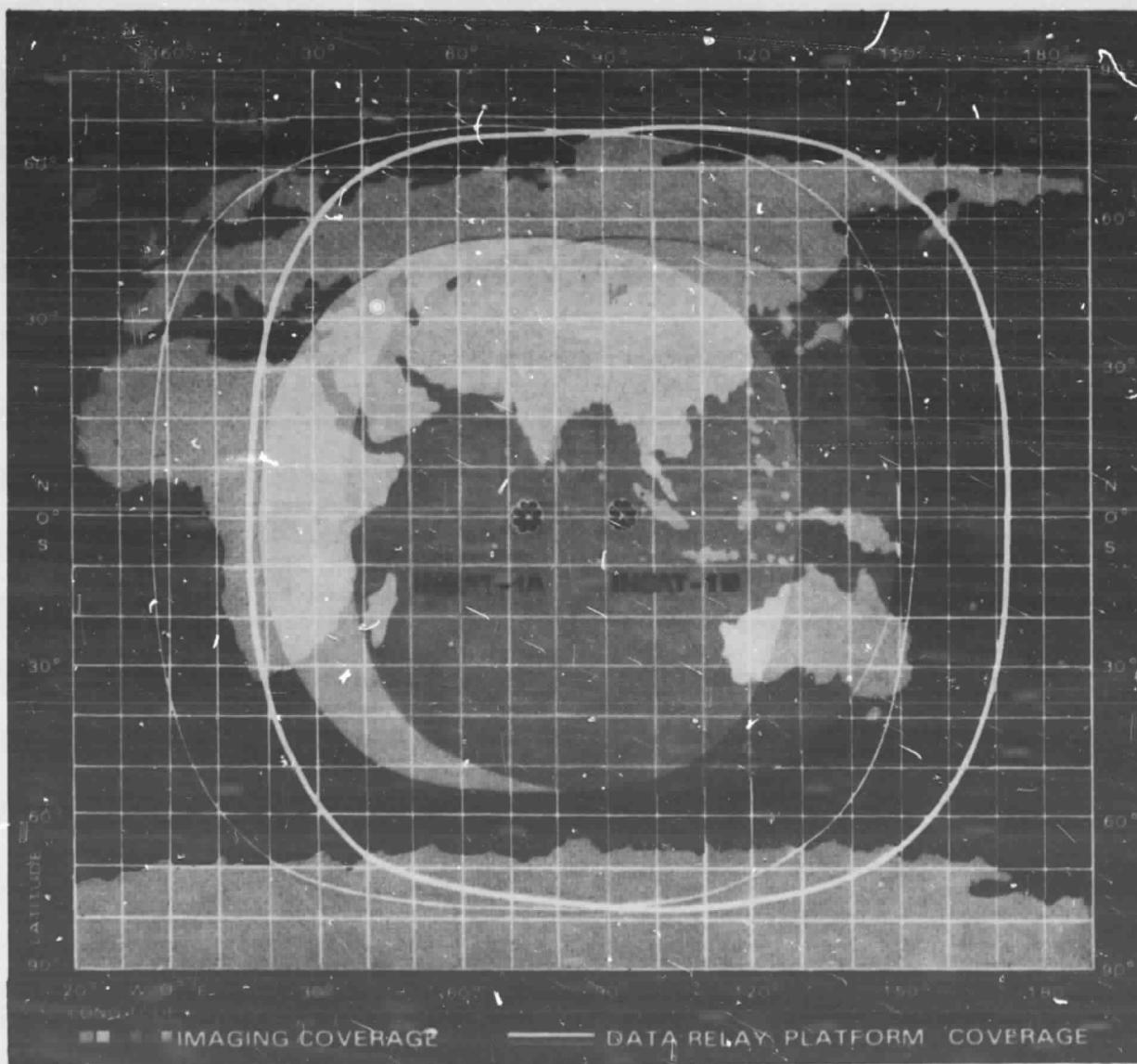


Fig. 1

The INSAT-1A and -1B system concept is outlined in Figure 2 and requires the spacecraft segment to include 12 transponders operating at 5935-6424 MHz (Earth-to-satellite), 3710-4200 MHz (satellite-to-Earth) for thick route, thin route, and remote area communication and TV program distribution; and 2 transponders operating in 5855-5935 MHz (Earth-to-satellite) and 2555-2635 MHz (satellite-to-Earth) for direct TV broadcasting to augmented low cost community TV sets in rural areas, radio program distribution, national TV networking and disaster warning.

A Very High Resolution Radiometer (VHRR) instrument with visible (0.55-0.75 micron) and infrared (10.5-12.5 micron) channels with resolutions of 2.75 km and 11 km, respectively, and with full Earth coverage is included in the satellite to provide full frame image every 30 minutes for round-the-clock, half-hourly synoptic observations of weather systems including cyclones over India and the adjoining land and sea areas, sea surface and cloud-top temperatures, water bodies and snow-mapping as well as collection and transmission of meteorological, hydrological and oceanographic data from unattended remote automatic data collection platforms (DCPs) to a central data processing center. This will permit timely warning of impending disasters from cyclones, floods, etc., and dissemination of meteorological information for agricultural and other purposes. Using the INSAT TV capability, the warnings can directly reach the population in the areas likely to be affected.

A data channel is provided for relay of meteorological, hydrological and oceanographic data from unattended land and ocean-based data collection transmission platforms.

The telecommunications component will provide over 8,000 two-way long distance telephone circuits potentially accessible from any part of India.

The television component of the INSAT-1 system will provide:

- . Direct TV broadcasting to augmented community TV receivers in rural areas for which direct TV broadcast coverage has been identified as more economical.
- . Nationwide TV coverage in one step.
- . National networking of terrestrial TV transmitters.
- . Radio program distribution.

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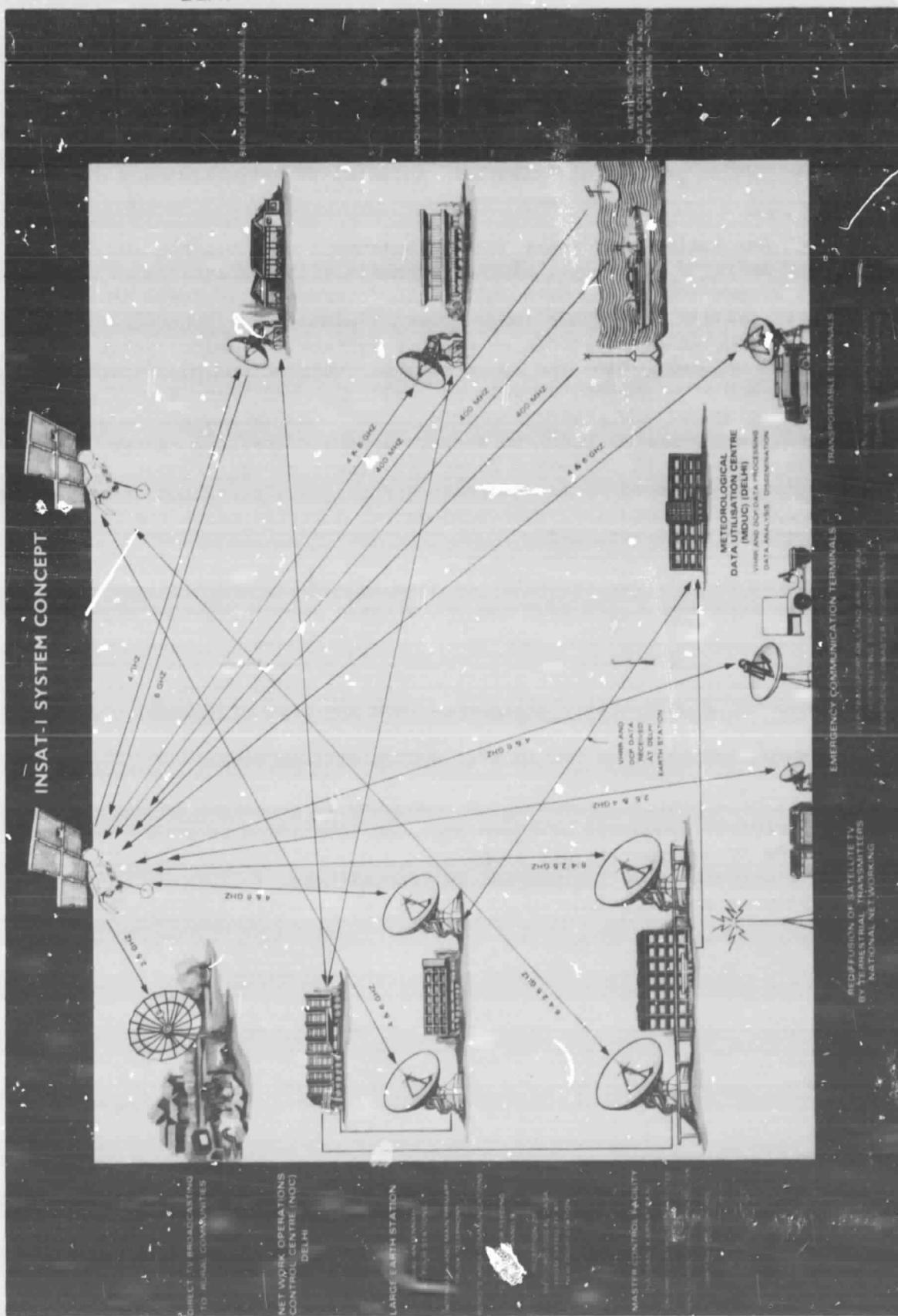


Fig. 2

BASIC SPACECRAFT DESCRIPTION

The principal features of the INSAT satellite are:

- . Body stabilized design
- . Two operating wheels, momentum bias system
- . Single wing-deployable solar array
- . Two deployable antenna reflectors, C-band odd transmit/receive and C-band even/S-band transmit
- . Omnidirectional TT&C antenna coverage
- . Bipropellant propulsion system for attitude control, stationkeeping and apogee burn maneuvers
- . Two-axis scanning radiometer (VHRR) with 8-inch diameter optics and passive radiation cooler
- . Nondeployed configuration compatible with 8-foot Delta fairing and vertical mount in STS cargo bay
- . Approximate mass 2540 pounds into transfer orbit

The principal geometry of the INSAT satellite is as follows:

Satellite (stowed)	272 x 180 x 155 cm (107 x 71 x 61 inches)
Overall spacecraft envelope (with PAM-D)	256 cm (100.88 in) above separation plane 218 cm (86 in) diameter
Satellite (antennas, array and sail deployed)	584 x 1793 x 138 cm 230 x 706 x 54.5 in)

The principal subsystems of the INSAT satellite are:

- . Communications
 - Channels - 12 C-band at 32 dBW
 - 2 S-band at 42 dBW
 - Traveling Wave Tubes - 12 at 4.5 Watts
 - 2 at 50 Watts
- . Command Ranging and Telemetry
 - Uplink - 6 GHz
 - Downlink - 4 GHz (250 nw)
- . Propulsion
 - MMH/N₂O₄ - 1370 pounds of liquid fuels
 - Apogee Kick Motor 100 lbf (Marquardt R-4D-11) - 312 Sec Isp
 - Reaction Control System - 12 Thrusters at 5.0 lbf (Marquardt R-6)
- . GH₂ Pressurant
 - 1 Tank
- . Attitude Control
 - 2 Momentum Wheels
 - 1 Reaction Wheel

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INSAT-1A SYNCHRONOUS ORBIT SATELLITE CONFIGURATION

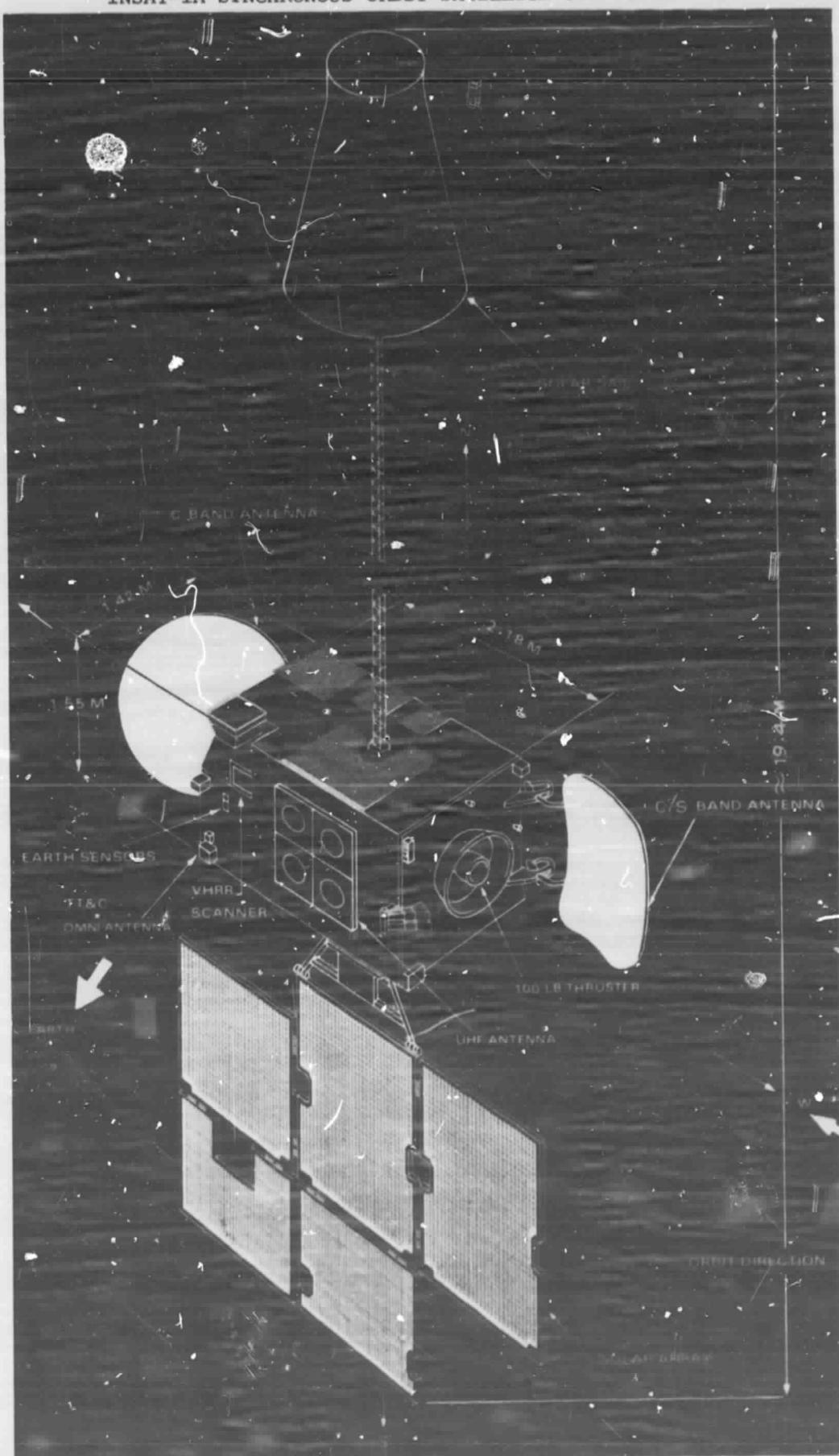


Fig. 3

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- Power
 - Solar Arrays - 900 W
 - 2 Nickel Cadmium Batteries - 51 Amp Hrs Total
- Thermal Control - Active
 - Propellant Tanks, Thrusters, Critical Components
 - Batteries

LAUNCH VEHICLE DESCRIPTION

The INSAT-1A spacecraft will be launched by the thrust-augmented NASA Delta 3910 launch vehicle (Figure 4). The Delta 3910 launch vehicle's characteristics are shown in Table 1. A schematic of the launch vehicle is shown in Figure 5. This will be the 161st flight for Delta. Of the previous 160 flights, 147 have successfully placed satellites into orbit.

LAUNCH VEHICLE FOR THE INSAT-1A MISSION
DELTA 3910

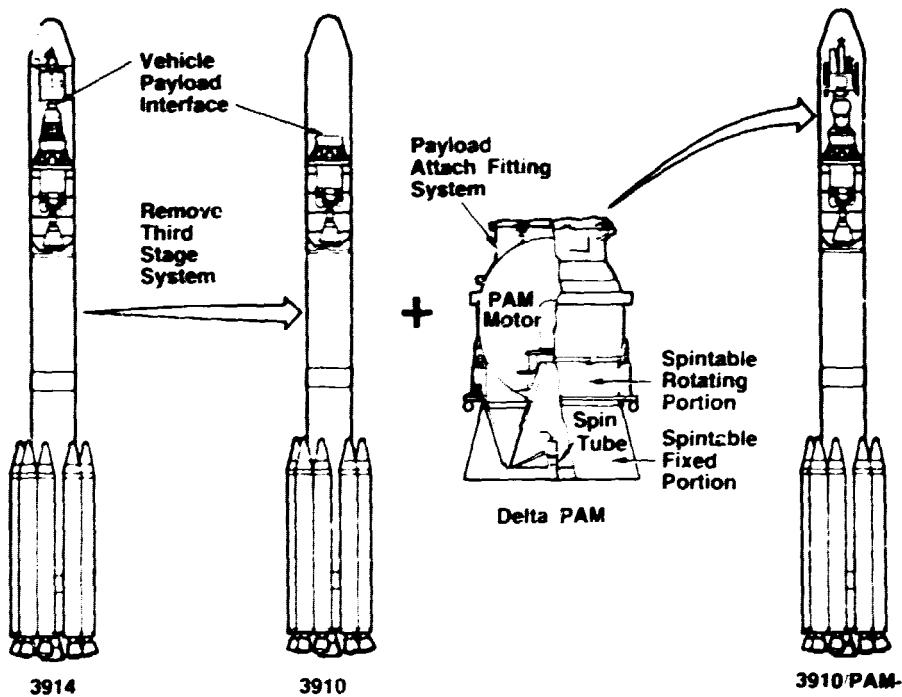


Fig. 4

Delta is managed for the NASA Office of Space Transportation Operations by the Goddard Space Flight Center, Greenbelt, MD. Launch operations management is the responsibility of the Kennedy Space Center's Deployable Payloads Operations Division. The McDonnell Douglas Astronautics Corporation, Huntington Beach, CA, is the Delta prime contractor for the vehicle and launch services.

Overall, the Delta 3910 is 35.5 meters long (116 ft), including the spacecraft shroud. Lift-off weight is 190,630 kg (420,269 lb) and lift-off thrust is 2,058,245 newtons (547,504 lb), including the startup thrust of six of the nine solid motor strap-ons (the remaining strap-ons are ignited at 62 seconds after lift-off).

The first stage booster will be an extended long-tank Thor powered by the Rocketdyne RS-27 engine system which uses Hydrazine (RP-1) and liquid oxygen propellants. Pitch and yaw steering is provided by gimballing the main engine. The vernier engines provide roll control during powered flight and control during coast.

TABLE 1
DELTA 3910 LAUNCH VEHICLE CHARACTERISTICS

	Strap-On	Stage I	Stage II
Length	11.3 m (37.0 ft)	21.3 m (70.0 ft)	700.0 cm (276 in)
Diameter	101.6 cm (40 in)	243.3 cm (96 in)	139.7 cm (55 in)
Engine Type	Solid	Liquid	Liquid
Engine Manufacturer	Thiokol	Rocketdyne	TRW
Designation	TX-526	RS-27	TR-201
Number of Engines	9	1 (+2VE)	1
Specific Impulse Avg.	229.9	262.4	302
Thrust (per engine) (Avg.)	407,000 N (91,520 lb)	911,840 N (205,000 lb)	43,398 N (9,756 lb)
Burn Time	58.2 (sec)	228 (sec)	315 (sec max)
Propellant	TP-H-8038	RP-1 (LOX oxid.)	A-50 (N ₂ O ₄ oxid.)

DELTA 3910 - VEHICLE ELEMENTS

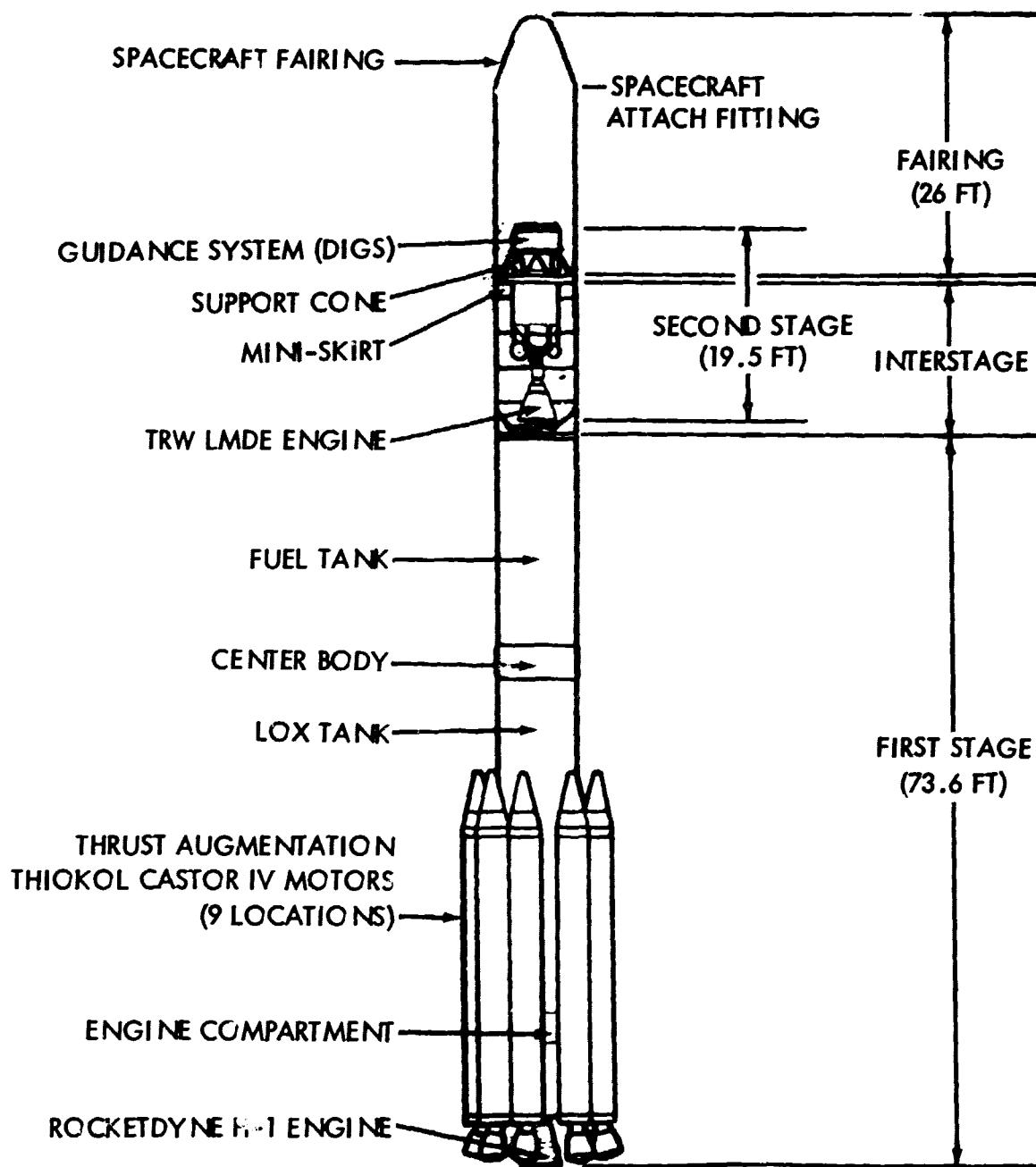


Fig. 5

The second stage is powered by the TRW TR-201 liquid bipropellant engine using N_2O_4 as the oxidizer and Aerozene-50 as the fuel. Pitch and yaw steering during powered flight is provided by gimbaling the engine. Roll steering during powered flight and all steering during coast are provided by a GN_2 cold gas system.

The guidance and control system of the vehicle is located on top of the second stage. The strap-down Delta Inertial Guidance System (DIGS) provides guidance and control for the total vehicle from lift-off through attitude orientation. The system is composed of a digital computer provided by Delco and either the Inertial Measurement Unit (IMU) provided by Hamilton Standard or the Delta Redundant Inertial Measurement System (DRIMS) developed by MDAC.

First and second stage telemetry systems are similar, both combining the use of pulse duration modulation and frequency modulation. Critical vehicle functions are monitored to provide data for determining which components, if any, are not functioning properly during ascent.

Tables 2 through 5 show the flight sequence of events, the mission requirements, the flight mode description, and the predicted orbit dispersion. Figure 6 shows the vehicle ascent profile for the INSAT-1A mission.

At lift-off, six Castor IV solid rocket motors are ignited on the launch pad and burn out at 56.95 seconds. At 62 seconds, the remaining three Castor IV solid rocket motors are ignited and burn out at 119.150 seconds. The six ground-lit solid motors are jettisoned in groups of three at 70 and 71 seconds with the final set of three solids jettisoned at 125.5 seconds. First stage separation occurs at 231.824 seconds with the spacecraft fairing jettisoned at 241 seconds.

At second stage cutoff (SECO), the vehicle is at an altitude of 134.9 NM and on an impacting trajectory with an apogee of approximately 137.4 NM. Following SECO, pitch and yaw commands are executed by the Delta vehicle to provide the required burn attitude for the PAM-D stage. One hundred eighteen seconds prior to stage II-III separation, a low thrust ullage is performed to settle the liquid propellant Apogee Kick Motor (AKM) of the spacecraft. Two seconds prior to stage II-III separation, the third stage is spun up to 40 rpm. With the separation of the Payload (third stage (PAM) and spacecraft) from the second stage, NASA/Delta responsibilities are concluded. PAM ignition occurs at 1165 seconds and burns for 86.37 seconds placing the payload into a geostationary transfer orbit.

TABLE 2
INSAT-1A MISSION SEQUENCE OF EVENTS

<u>EVENT</u>	<u>TIME (SEC)</u>
Stage 1 Lift-off	0
(6) Solid Motors Burnout	56.950
(3) Solid Motors Ignition	62.000
Jettison (3) Solid Motor Casings	70.000
Jettison (3) Solid Motor Casings	71.000
(3) Solid Motors Burnout	119.150
Jettison (3) Solid Motor Casings	125.500
Main Engine Cutoff (MECO)	223.824
Vernier Engine Cutoff (VECO)	229.824
Stage I-II Separation	231.824
Jettison Fairing	241.000
Second Engine Cutoff Command	547.336
Engine Cutoff--Stage II (SECO)	547.741
Start Payload Ignition Time Delay Relay	1125.555
Fire Spin Rockets	1125.555
Payload Separation (Jettison Stage II)	1127.555
PAM Ignition	1165.555
PAM Burnout	1251.925
Spacecraft Separation (Jettison PAM*)	2451.925*
AKM Ignition (First Apogee)	20181.853

*To be ground commanded approximately 20 minutes after PAM B. O.

TABLE 3
MISSION REQUIREMENTS

NOMINAL ORBIT PARAMETERS AT SPACECRAFT INJECTION

Apogee Altitude	19,323 NM
Perigee Altitude	90 NM
Inclination	28 4 Degrees
Spin Rate	40 RPM
SPACECRAFT WEIGHT (AT LIFT-OFF)	2540 lb

TABLE 4
FLIGHT MODE DESCRIPTION

Launch from PAD 17A at ESMC
 Launch Window is 1:28 a.m. to 2:47 a.m., EST
 Six Solids Ignited at Lift-off
 Three Solids Ignited at 62 seconds
 Fairing Separation Occurs at 241 seconds
 Second Stage is Suborbital and Impacts West of Africa at roughly
 1 degree West Longitude and 10 degrees South Latitude

TABLE 5
PREDICTED ORBIT DISPERSIONS (95% PROBABILITY)*

Apogee Altitude	+200 -1800 NM
Perigee Altitude	+1 -25 NM
Inclination	+1.0 Degree
Spin Rate	+4 RPM

*INSAT-1A final weight exceeds agreed to P/L weight capability for trajectory required and 3 σ probability is now only 95% of achieving transfer orbit altitudes requested.

INSAT-1A SECOND STAGE TRAJECTORY SCHEMATIC

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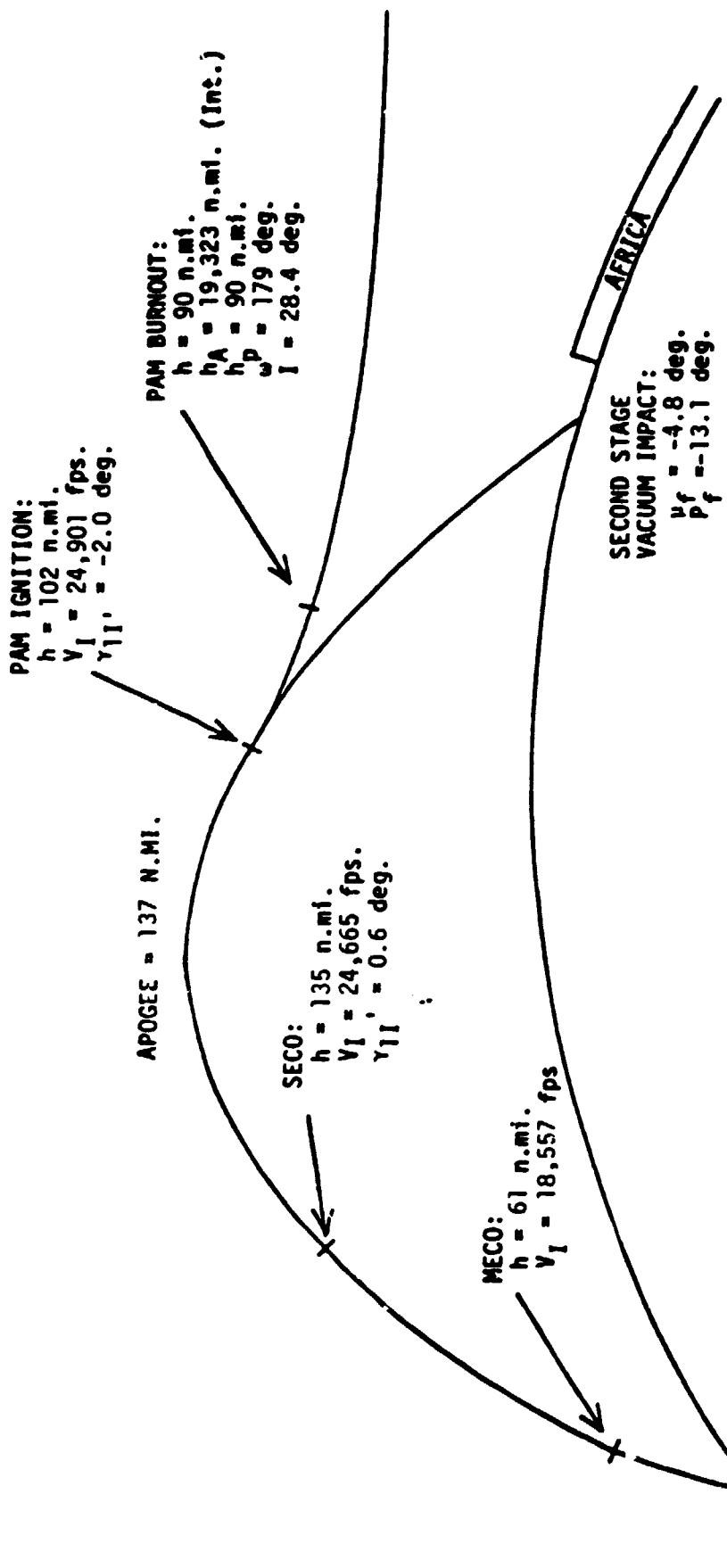


Fig. 6

MISSION SUPPORTRANGE SAFETY

Command destruct receivers are located in the first and second stages and are tuned to the same frequency. In the event of erratic flight, both systems will respond to the same RF modulated signal sent by a ground transmitting system upon initiation by the Range Safety Officer.

LAUNCH SUPPORT

The Eastern Space and Missile Center (ESMC), the launch vehicle contractor, McDonnell Douglas, and NASA will supply all personnel and equipment required to handle the assembly, prelaunch checkout, and launch of the Delta vehicle. GSFC will provide technical advisory personnel to DOS, if required.

TRACKING AND DATA SUPPORT

ESMC Range stations will track the first and second stages. A nominal trajectory and orbit will be provided approximately 30 minutes after launch based on this data and the assumption that the PAM was nominal. DOS has established stations that will be used to determine the final transfer orbit and also to provide data necessary for the firing of the PAM and the apogee motor.

GROUND COMPLEX

The Master Control Facility for INSAT-1A satellite orbit raising and on-orbit control and management is being established in the Hassan District of Karnataka.

Telecommunications Ground Segment

The initial INSAT-1 Telecommunications Ground Segment is outlined in Figure 7 and includes the following:

- . Five Large Earth Stations
- . Thirteen Medium Earth Stations
- . Eleven Remote Area Terminals
- . One Road Transportable Terminal
- . Two Jeep-transportable/air-liftable emergency communication terminals
- . A Network Operations Control Center (NOCC) for coordination and control of all 6/4 GHz utilization Earth stations
- . Four of the five large Earth stations linked with main switching centers of the national telecommunications plants (Bombay, Calcutta, Delhi and Madras) will have a second antenna system with associated electronics for simultaneous utilization of INSAT-1A and INSAT-1B satellites

Meteorological Ground Segment

The INSAT-1 Meteorological Ground Segment facilities comprise the following:

- . A Meteorological Data Utilization Center (MDUC) at New Delhi for processing INSAT-1 VHRR and DCP data which will be received at the Delhi Earth Station of P&T and transmitted to MDUC realtime over a microwave link.

INSAT-1 GROUND FACILITIES



Fig. 7

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- Secondary Data Utilization Centers (SDUC) located in various forecasting offices of the India Meteorological Department (IMD) will receive processed images from MDUC over telecommunications lines (including INSAT-1 circuits).
- About 100 DCPs deployed all over the country, including some over oceans, and disaster warning facility.
- The Meteorological Data Utilization Center shall have facilities for processing, analysis and storage of INSAT-1 VHRR and DCP data. Each DCP shall be capable of handling 10 sensors. The primary meteorological sensors associated with the DCPs are: air temperature, wet bulb temperature and relative humidity, wind speed, wind direction, atmospheric pressure, DCP housing temperature, rainfall, sunshine and sea surface temperature.

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Thiokol Corporation Huntsville Alabama	Castor IV Strap-on Solid Fuel Motors
TRW Redondo Beach, California	TR-201 Second Stage Engine
Delco Santa Barbara, California	Guidance Computer